Cairo Air Improvement Project

Compressed Natural Gas Component

Institutional Suport Plan for CNG Operations

Chemonics International, Inc.
USAID/Egypt, Office of Environment
USAID Contract No. 263-C-00-97-00090-00

January 1999

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Acronyms and Abbreviations

CAIP	Cairo Air Improvement Project
CATA	Central Administration for Training Affairs (of the CTA)
CMP	Computer management professionals
CNG	Compressed natural gas
CTA	Cairo Transit Authority
EMIS	Electronic maintenance information system
GCBC	Greater Cairo Bus Company
ICS	Inventory control section
km	Kilometer(s)
MAF	Material approval form
MRF	Material request form
O&M	Operations and maintenance
OEM	Original equipment manufacturer
PBPM	Performance Based Project Milestone
PM	Preventive maintenance
QA/QC	Quality assurance/quality control
RM	Routine maintenance
USA	United States of America

1. Introduction

Successful compressed natural gas (CNG) bus fleet operation and maintenance (O&M) in Cairo will require a major cultural change in the present bus maintenance organization, in order to introduce modern maintenance, management, and quality practices. The goal of the Cairo Air Improvement Project (CAIP) CNG Team's efforts will be to establish at each of the two bus companies—Cairo Transit Authority (CTA) and Greater Cairo Bus Company (GCBC)—a separate maintenance organization specifically for the CNG buses.

The CNG Team will provide these organizations with the leadership, training, tools, and other resources needed to implement modern management and quality practices, which will include emphasizing preventive rather than corrective maintenance; continuous quality improvement; and full accountability for time, spare parts, supplies, and other resources. These new organizations will initially support the pilot CNG bus fleets. As the number of CNG buses grows, the CNG Team will work with CTA and GCBC to institutionalize these organizational changes, so that by the time the switch to CNG is complete, the entire operations and maintenance system will have been reformed.

The CNG Team, with assistance from the bus companies, has been studying the existing diesel bus O&M practices in an effort to characterize the baseline Egyptian diesel transit bus environment. After studying this environment, the CNG Team developed a proposed new organizational structure and reporting relationship for the CNG bus garages that can enhance the current system, as well as provide the necessary new equipment and management practices. This effort also included development of proposed staffing requirements for maintenance personnel and management staff.

The new program is based on CNG transit experience from around the globe, and uses straightforward requirements to allow efficient implementation into the CTA and GCBC organizations. Some technologically sophisticated systems are proposed, but they can be implemented with minimal training and will provide superior capabilities for monitoring and ensuring the success of the new CNG programs at CTA and GCBC. To conclude the Performance Based Project Milestone (PBPM) #3, the CNG Team developed a suggested implementation plan to move CTA and GCBC from the current diesel transit program to the proposed new CNG bus program.

After completion of the milestone report, the CNG Team met with management from CTA and GCBC on 10 December 1998 for a preliminary review. The review covered

the inclusion of the proposed garages in the corporate structures of each organization, the proposed organization chart for the actual CNG garages, and the general topic of the electronic maintenance information system (EMIS).

The chairmen of CTA and GCBC were pleased with the report findings and had already envisioned that the CNG garages would become separate entities in their corporate structures. In the original report, the new CTA Nasr City CNG facility would have become its own Central Administration in the CTA corporate structure. While the chairman of CTA did not agree to make the new CNG facility into its own Central Administration, it will become a separate entity in the CTA corporate structure, with its own general manager reporting directly to the chairman of CTA. At GCBC, the new Katameya CNG facility will become a new facility under the Branch Operations Section.

Both the bus companies are agreeable to the implementation of the EMIS. The companies previously thought of implementing a system like this throughout their organizations, but have not done so to date. They are looking forward to developing these systems in their CNG garages and then using them as a model for the rest of their diesel garages.

After awarding an initial contract to a US chassis/engine supplier, the CNG Team will begin developing detailed management procedures for CNG bus and minibus O&M. These will include:

- Schedules for inspections
- Procedures for routine and preventive maintenance
- Management of spare parts and supplies
- Monitoring, reporting, following up, and solving maintenance problems.

These new procedures will present a major cultural change. The transition from the present system, to one in which every driver and mechanic (and his/her supervisor) are provided with objective measures of quality and productivity, will need to be managed carefully, with full participation by employee representatives. To make this transition successfully, managers and supervisors will need to change their approach from "bossing" to "coaching," and will need to use the monitoring results as an aid to targeting training and coaching assistance.

2. Existing CTA and GCBC Transit Operations

Under CAIP Task 5.1, the CNG Team was required to carry out a baseline study to characterize the existing operation and maintenance programs at CTA and GCBC for diesel transit buses.

In order to understand what changes might be necessary inside the CTA and GCBC garages, the CNG Team needed to determine what maintenance practices are currently being followed, what maintenance schedules are in force, and what maintenance equipment is available to CTA and GCBC mechanics and technicians. In addition, the team needed to know what maintenance and performance records are kept on the fleet vehicles, i.e., fuel, oil, spare parts, automotive fluids, etc. Understanding the management structure at the transit garages, as well as the CTA and GCBC corporate management structure, was also imperative to understanding current practices. During the institutional development phase of the task, understanding who will be responsible for any necessary changes to current practices and procedures will also be essential.

Armed with this information, the CNG Team developed a proposed institutional structure for CNG operations, presented in Section 3. The team has confidence that the new structure could be successfully implemented within both CTA and GCBC.

This section discusses current management structure, overall maintenance programs, inventory control system for parts, training programs, fire fighting capability, and the nightly maintenance regimens for both bus companies.

2.1 Current Management Structures at CTA/GCBC

CTA is one of the largest public transportation authorities in Egypt. Currently, the company is operating 2,500 buses and 790 minibuses in addition to providing tram, metro, and ferryboat service. CTA operations include about 400 lines, nearly 80 percent of which are for buses and approximately 15 percent for minibuses. The vehicle fleet averages between 250–400 km per day and transports 4 million passengers. The company has approximately 40,000 employees, including headquarters staff, 2 central workshops, and 15 garages. Under the current corporate structure, CTA's 15 transit and minibus garages are managed by seven Central Administration "Sectors." Each sector manager reports directly to the Chairman.

GCBC is the second largest transit company in Greater Cairo, and has the same ownership as the CTA. The company operates more than 900 buses (no minibuses)

distributed over four garages. A single Branch Operations Section manages GCBC's four transit bus garages. The manager of the Branch Operations Section reports directly to the Chairman.

Figures 1 and 2 depict the corporate organizational charts for CTA and GCBC, respectively. Section 3 discusses how the CNG Team proposes to integrate the two new CNG garages into the existing CTA and GCBC organizational structures.

2.2 Current Maintenance Program for Vehicles

Clearly, one of the main concerns of the CNG Team is the maintenance program that CTA and GCBC will be able to implement for the new CAIP CNG transit buses and minibuses coming to Cairo. A baseline study's effort to characterize the existing diesel maintenance programs was carried out to confirm that the proposed program will be feasible (because it will not be overly complex in comparison to the existing program). The existing maintenance departments are organized into vehicle maintenance "teams" to do daily, bi-weekly, and oil change maintenance, as well as to make unforeseen repairs. The technical departments schedule vehicle maintenance and keep records of all maintenance and repair for each vehicle.

2.2.1 Maintenance Teams

The CTA and GCBC transit garages have their vehicle mechanics and technicians organized into maintenance teams. Each team is assigned to work on 30–50 specific buses. Each team is made up of approximately 15 mechanics, 3–4 electricians, and 6 miscellaneous staff members, or approximately 25 employees. Each team only works on the specific vehicles to which they are assigned. The important thing to note about the existing maintenance teams is that they understand the concept of "teamwork" on the job.

2.2.2 Types of Maintenance

The existing CTA and GCBC maintenance programs can be broken down into bi-weekly maintenance, oil changes, emergency service, and capital repair.

Bi-Weekly Maintenance

The bi-weekly maintenance program for vehicles is carried out by the first (or morning) shift of garage employees. Because of the current timing and maintenance scheduling, this means that every vehicle has a complete check-up almost every three weeks. The bi-weekly maintenance includes:

- Checking the engine and performing necessary maintenance, such as examining all engine parts and elements for wear, changing filters as scheduled, checking and tightening belts, and inspecting the cooling system and engines supports.

Figure 1

Corporate organization chart for CTA

Figure 1

Corporate Organization Chart for CTA

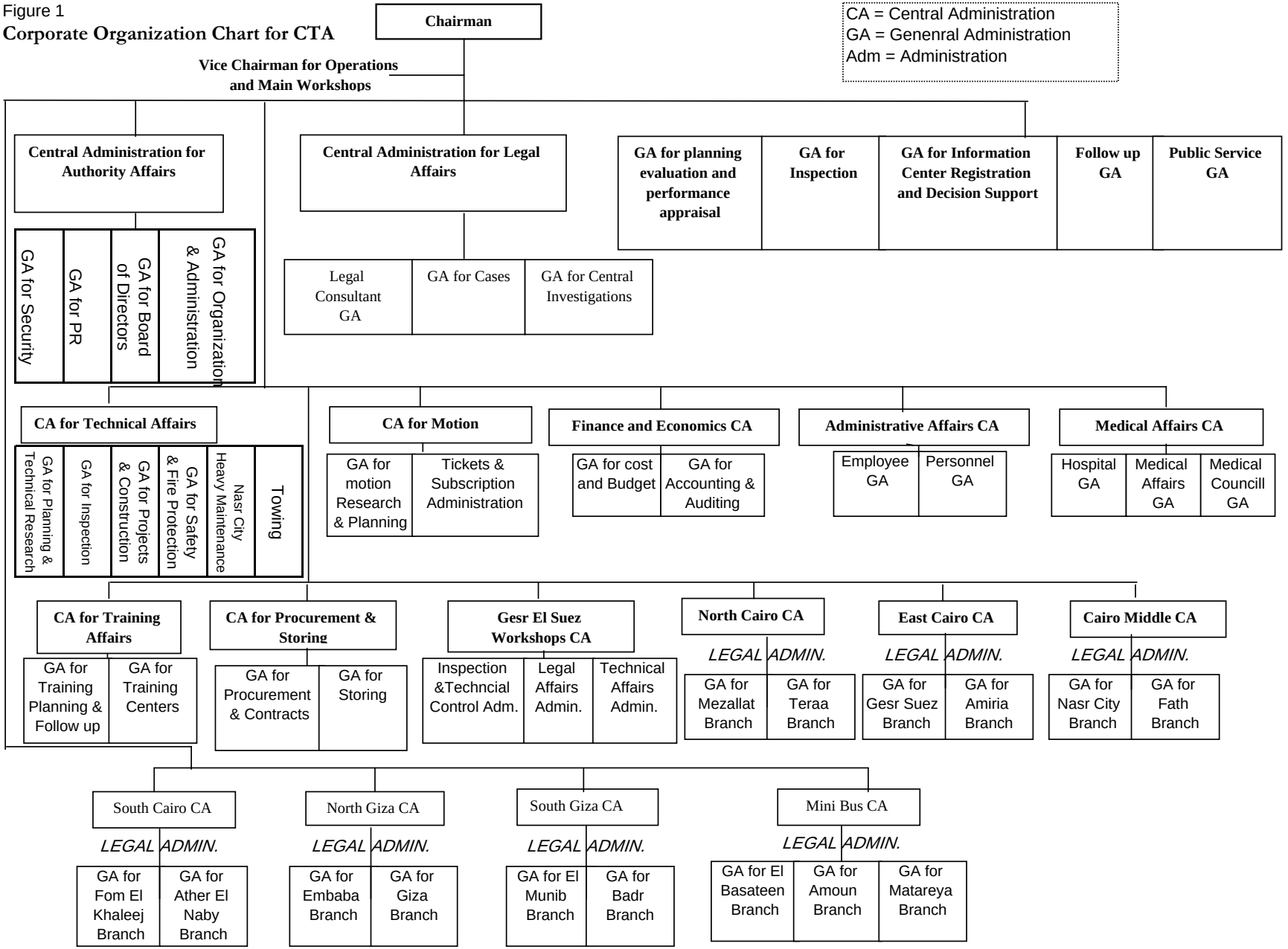
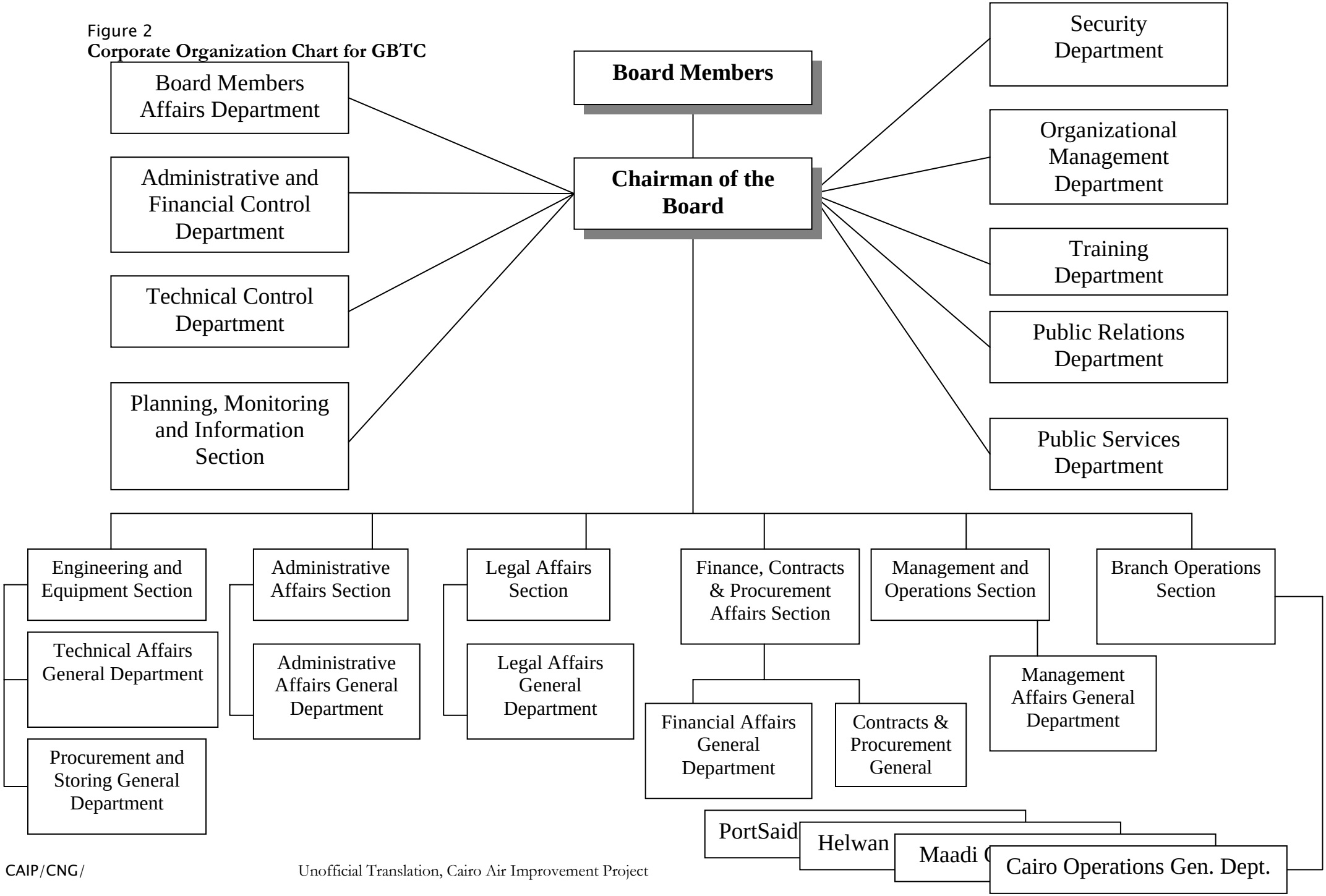


Figure 2: Corporate organization chart for GCBC

Figure 2
Corporate Organization Chart for GBTC



- Checking the air circuit and brakes with regards to the eccentric system, diaphragms, brake pad linings, brake drums, draining water from condensed air tanks, cleaning those tanks, and checking for air leakage in the circuit. Brakes are given a safety check.
- Any required transmission maintenance.
- Check steering, suspension, seats, and columns.
- Check electrical system.
- Check sheet metal and welds.
- Check wires and harnesses.
- Wash vehicles.

Oil Changes

Oil changes are carried out every 4,000-km for the existing CTA and GCBC diesel transit vehicles. Because the vehicles do not necessarily accumulate 4,000 km every two weeks, the oil changes are a separate procedure from the bi-weekly maintenance program.

Emergency Service and Maintenance

This type of service and maintenance is provided for vehicles that have broken down suddenly. These vehicles are either towed back to the garage or somehow make it back on their own. Emergency repair service can be done on the vehicle's main systems (including engine, transmission, starter, generator, air pump, fuel pump, axles, brakes, etc.) right in the transit garages. Extensive repairs and vehicle rebuilds are done in capital repair and overhauling.

Capital Repair and Overhauling

The capital repair and overhauls for CTA and GCBC transit buses are done at CTA's Gesr El Suez and Nasr City heavy maintenance facilities; capital repair and overhauls for CTA's minibuses are done at CTA's Nasr City heavy maintenance facility. Along with the capital repair and overhauls, both the Gesr El Suez and Nasr City heavy maintenance facilities are available for any sudden extensive repair work for CTA and GCBC transit or minibuses.

Capital repair and overhauls for vehicles includes a complete renovation of the vehicle, including engine rebuild/replacement, transmission rebuild/replacement, and the construction of new vehicle bodies. New transit vehicles undergo their first overhaul after 6 years of service. After the first overhaul, the vehicles are rebuilt every 3 years.

2.2.3 Maintenance Department Workshops

The two companies, CTA and GCBC, have similar maintenance equipment and follow the same maintenance procedures. Listed below are the types of workshops and equipment that are available at both companies:

- Supplies workshop (brakes, air pump, water pump)
- Electricity workshop
- Drive-train workshop
- Engine workshop
- Welding workshop
- Filing workshop
- Soldering workshop
- Sheet metal workshop
- Battery workshop
- Carpentry workshop
- Upholstery workshop

2.2.4 Individual Vehicle Data Collection

The existing technical departments maintain individual file folders for each bus in the fleet. In each folder, the department supervisor records all relevant data on required repairs, parts, and fluids consumption. Currently, the maintenance department is tracking the consumption of fuel, oil, brake linings, belts, and tires. Table 1 shows typical fuel and oil consumption at both CTA and GCBC.

Table 1
Fuel and Oil Consumption by Vehicle Make

Vehicle Make	Fuel Consumption (liters/100 km)	Oil Consumption (kilograms/100 km)
Air cooled vehicles	58.26	1.08
Nassar 871	60.64	0.77
Nassar 966	54.48	0.62
Mercedes made in Persia	34.56	1.65

2.3 Inventory Control System for Parts

One of the major concerns cited in at least one earlier report about CTA and GCBC maintenance programs was the lack of control over spare parts usage and parts

inventory availability[1]. The CNG Team is very concerned about this issue because the imported CAIP CNG chassis (including engines and fuel systems) will require a consistent supply of spare parts for proper preventive maintenance and repair. This is essential in enabling CTA and GCBC to provide high-quality CNG transit service in Cairo.

CTA and GCBC management explained their existing inventory control system during early meetings for Task 5.1. This system requires several signatures to obtain new spare parts, but the system is not automated or electronically tracked. As mentioned above, the technical departments manually record all parts used for a bus in the individual vehicle file folder for that bus.

To obtain a necessary spare part, the maintenance mechanics first go to their direct supervisors for approval to make the repair. The mechanic gets his/her supervisor's signature on a parts request form. The mechanic must then get approval from the garage engineer on duty, as well as the engineer's signature on the parts request form. The mechanic then takes the parts request form, along with the broken or used part that needs to be replaced, to the Used Parts Collection Department. This step excludes all small parts that are not practical to collect after damage, such as engine belts. The Used Parts Department receives the broken/used part from the mechanic and signs the parts request form.

The mechanic can then take the parts request form to the Parts Stores and receive the necessary part for his repair work. The completed parts request form is then placed in the individual bus's folder with the technical department to maintain proper parts usage record keeping.

This existing inventory control system is very thorough and is well designed to eliminate erroneous repair work. The system also allows for good manual record keeping for each vehicle. There does not appear to be any system in place, however, to track the parts inventories in the Used Parts Collection Department (for auditing purposes) or in the Parts Stores. This apparent lack of inventory control can lead to poor inventory tracking, along with the erratic parts supply problems mentioned in earlier reports.

Another probable cause for erratic parts supply in the existing CTA transit garages is the bureaucratic parts request system. Each transit garage must place its orders for new spare parts with its Sector Central Administration. The Sector Administration must then deliver the parts request to the CTA corporate Central Administration for Procuring and Storing. All of these current parts requests are done manually and take time to accomplish without the aid of computerized ordering and filing systems.

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[1] Kotb, Dr. Mohamed El, "Improvement of Public Transportation in Cairo Metropolitan Area," 1993.

2.4 Current Training Programs

The current training programs for CTA garage mechanics are coordinated through the CTA Central Administration for Training Affairs (CATA). Because of GCBC's smaller size relative to CTA, and the common ownership of both organizations, the current training programs for GCBC garage mechanics also are coordinated through the CATA. The extensive employee training provided at CTA's CATA varies from specialized technical programs to management preparation. The CATA has its own facilities and a training unit staff of nearly 200. The unit is well organized to ensure appropriate course selection for new employees as well as follow-up training on more specialized knowledge.

According to CTA and GCBC management, new garage employees go through rigorous training at the CATA and then continue into an on-the-job training program under the direct supervision of their assigned boss. This system is very logical and allows these new employees to get their initial detailed training at CATA and then begin working in the garage environment immediately. This system can work well for diesel transit garage employees because the CATA staff and the diesel garage supervisors are well versed in the diesel technology currently in use and can provide this insight directly.

2.5 Fire Fighting

The fire fighting response and fire suppression systems in the existing diesel garages are designed around an internal water circulation system, individual fire extinguishers in the garages, and individual fire extinguishers placed on each transit and minibus. Each garage at CTA and GCBC has 11 full-time fire fighting professionals on staff.

The water circulation system runs around the perimeter of each garage, with high-pressure spigots placed every 25 meters. Each garage has two 12.5-meter length hoses that can be attached to any of the spigots. Each garage is equipped with four 34 kilogram and two 50 kilogram trolley-mounted extinguishers. Each bus is equipped with two 6 kilogram powder-type extinguishers

2.5.1 Fire Safety Training

The fire fighting professionals at CTA and GCBC are required to go through initial training at the CATA to become certified for duty and are required to go through annual re-training programs offered by the Ministry of Interior's Fire Brigade Department. Supervisory level fire fighting professionals are required to go through the initial CATA training and an initial fire safety program at the Fire Brigade.

2.6 Nightly Maintenance Regimen

The night shift at each garage performs the preparation work on each vehicle for the next day of operation. This work includes any quick repair of defective vehicles, as well. This shift carries out the following activities:

- Fueling
- Complete check-up/inspection of vehicles returning from service, noting any relevant problems in each vehicle's technical folder
- Check fluid levels, fill if necessary
- Functional testing of mechanical and electrical systems, including lighting, doors, and mirrors
- Very minor repairs, if necessary
- Vehicle washing and parking for departure the following morning.

3. Proposed Institutional Structure

Based on the current CTA and GCBC corporate structures (presented above), and the additional requirements that the new CNG vehicles would impose on existing garages, the CNG Team proposes establishing the new CTA garage as its own entity under the CTA corporate structure and the new GCBC garage as a new General Department under the GCBC Branch Operations Sector. These proposed changes will allow the new CNG garages to act autonomously, rather than having to fit into the existing diesel sector/garage management structure. The new garage general managers will report directly to the chairman of their respective organizations. The proposed corporate structure changes for CTA and GCBC are presented in Figures 3 and 4.

Although the changes proposed for the placement of the new garages within the existing CTA and GCBC corporate structures are slightly different, the proposed organizational structures for the actual garages are identical. This proposed organizational structure for the new CNG transit bus garages at CTA and GCBC is shown in Figure 5. While this figure appears to only represent the organizational structure of the garages, it actually dictates the institutional changes required at CTA and GCBC to implement successful CNG transit- and minibus programs.

As the organization chart illustrates, the new garages will have nine directors reporting to the garage general manager, representing the new Maintenance, Technical, Safety, Transportation, Financial, Administration, Auditing, Legal, and Labor Relations Departments.

3.1 Maintenance Department

The Maintenance Department will obviously serve as one of the central hubs for O&M activities in the new CTA and GCBC CNG garages. The Maintenance Department should be in charge of routine maintenance (RM), preventive maintenance (PM), repair work, any heavy maintenance that can be carried out at the garage level, specialized repair shops (e.g., brakes, tire repair, battery charging), and the parts department. Routine inspection and maintenance of CNG fuel systems also will be included in the Maintenance Department's regular duties.

To aid the Maintenance Departments of the new CTA and GCBC garages to carry out their necessary tasks, the CNG Team proposes to enhance some of the existing

personnel management skills and implement several new maintenance technology-related

Figure 3
Proposed Corporate Organization Chart for CTA

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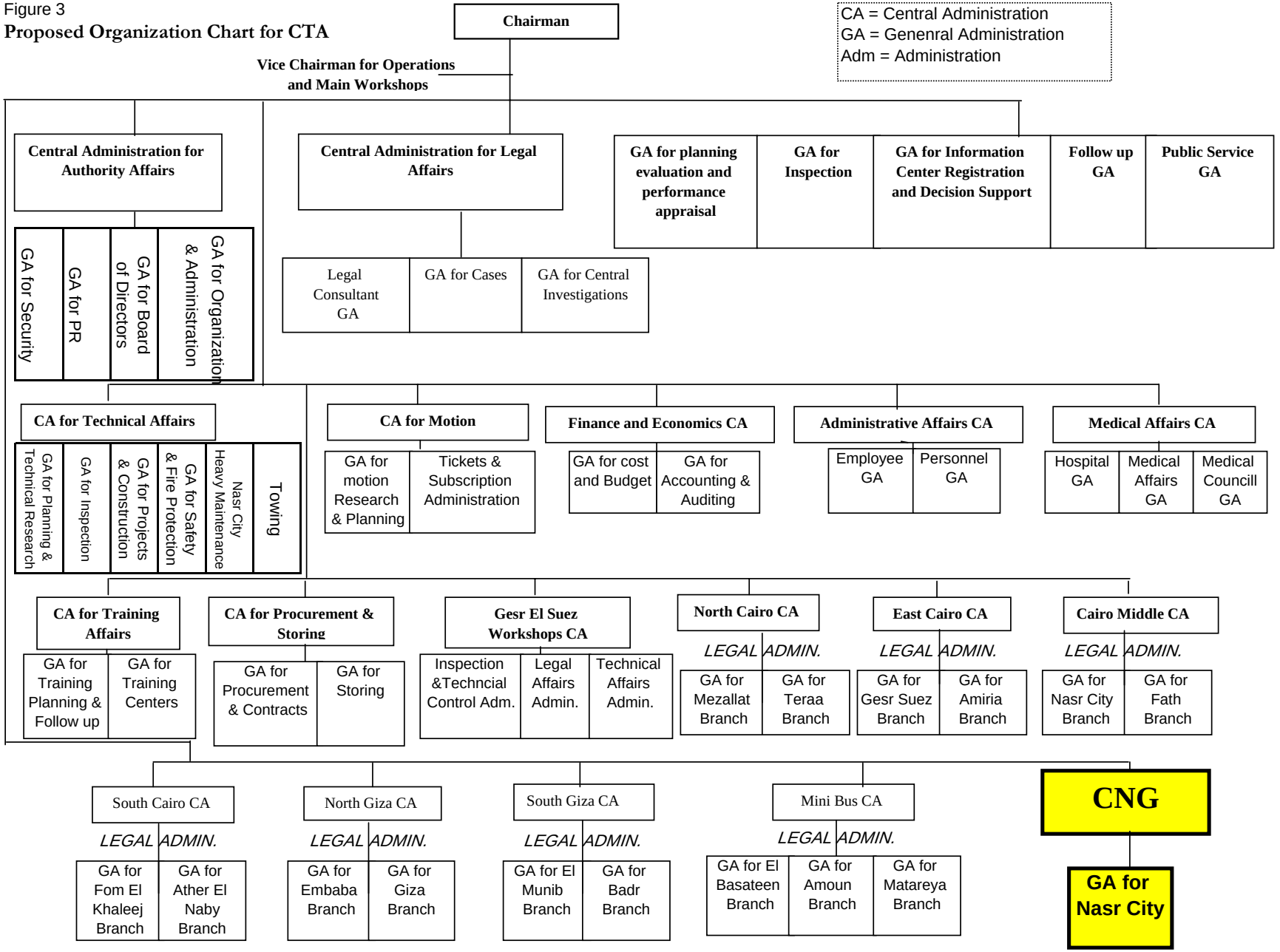

Figure 4

Proposed Corporate Organization Chart for GCBC

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Proposed Corporate Organization Chart for GCBC

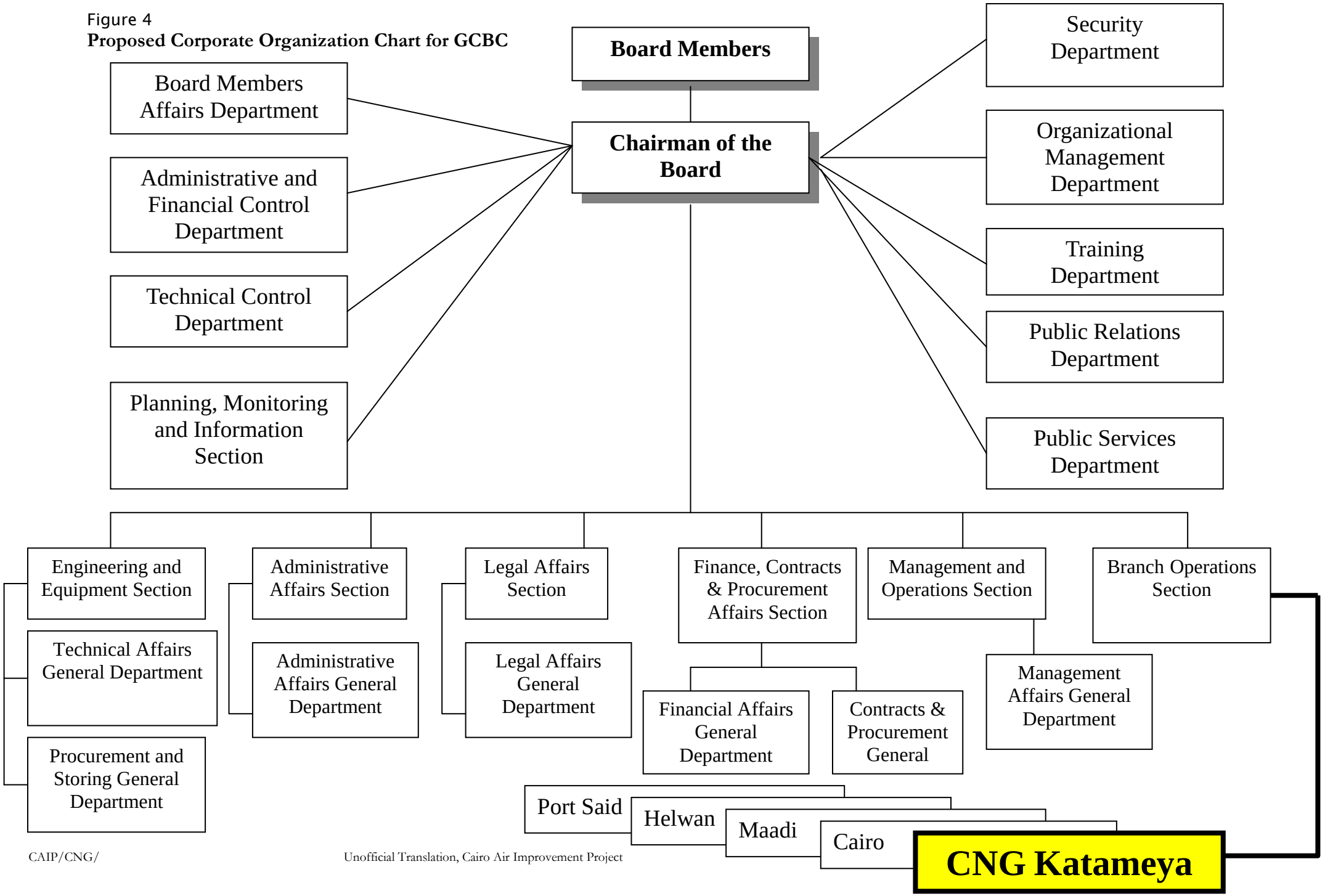

Figure 5

Proposed Organization Chart for CTA and GCBC CNG Garages

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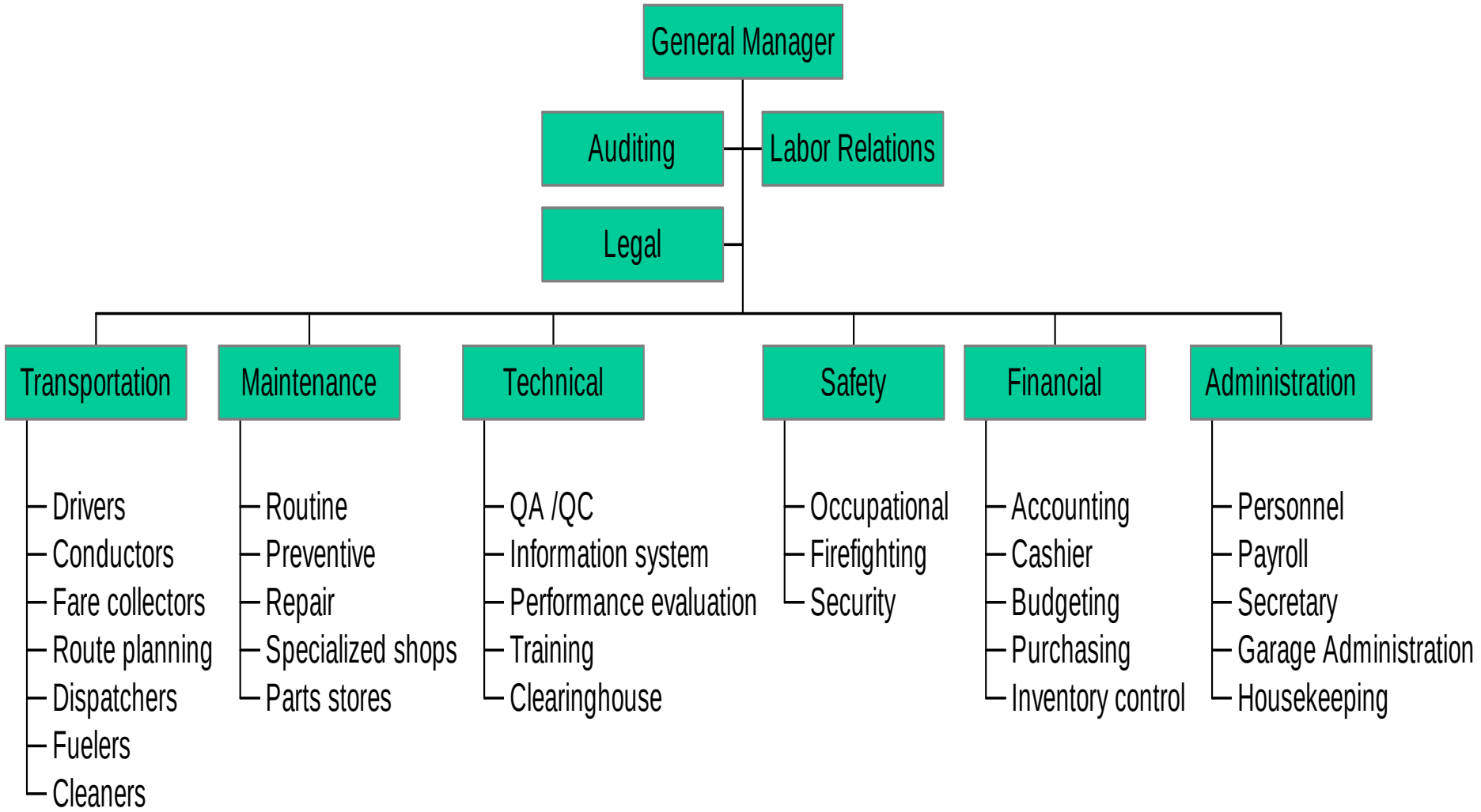
Proposed Organization Chart for CTA and GCBC CNG Garages



concepts. One of the CNG Team's major activities with the CTA and GCBC maintenance departments will be to restructure the existing "maintenance teams" used in the diesel garages (Section 2.2) into incentive-oriented "Performance Teams." The CNG Team also proposes to implement an electronic parts management system and an electronic maintenance scheduling system. Moreover, because proper CNG fuel system maintenance will be so important during the implementation phase of this project, the CNG Team will provide specific support for fuel system inspection and maintenance.

3.1.1 Performance Teams

As mentioned in Section 2.2, the existing CTA and GCBC diesel transit garages are organized with maintenance teams of roughly 25 staff who care for about 40 buses. Under these existing programs, the maintenance teams only work on the specific buses to which their teams are assigned—maintenance personnel from one team generally will not work on the buses assigned to another maintenance team. The CNG Team suggests enhancing this sense of teamwork by adding incentives for the maintenance teams that provide the best overall CNG buses to the public users. Performance indicators might include timely service and scheduled maintenance, maximum in-service usage, and even cleanliness. These new teams of CNG maintenance personnel would be called "Performance Teams."

The actual evaluation criteria, and associated incentive system for the Performance Teams' maintenance work will have to be determined in conjunction with CTA and GCBC management during the Task 5.2 (PBPM#4), but the overall goal is to motivate the CNG maintenance teams to provide the best and most reliable transit products to the consumer market.

3.1.2 Parts Management

The imported CAIP CNG chassis (including engines and fuel systems) will require a consistent supply of spare parts for proper maintenance and repair, to enable CTA and GCBC to provide high-quality CNG transit service in Cairo. As part of the solution to the previously mentioned problems of parts usage and inventory control, combined with the CNG bus requirements for a consistent spare parts supply, the CNG Team is proposing to implement an electronic maintenance information system (EMIS) at CTA and GCBC. This system will be capable of simultaneously monitoring parts usage and inventory, and interfacing with the purchasing department to assure timely acquisition of necessary parts for near-term maintenance and repairs.

As shown in Figure 3, the CNG Team recommends that the actual Parts Storage Department physically remain inside the Maintenance Department, for direct access to necessary vehicle maintenance and repair components. The parts flow from storage will be controlled through the above mentioned EMIS. In this effort to manage the flow of spare parts from the CNG Parts Stores, the EMIS system implementation will be accompanied by a parts request procedure for mechanics to requisition necessary spare

parts for their maintenance and repair needs. This new parts request procedure will augment the existing system at CTA and GCBC with the additional EMIS tracking of parts usage and inventory control.

In the present CTA and GCBC parts request systems, a mechanic who needs a spare part must receive approval signatures from his manager, the maintenance engineer in charge of his maintenance team, and from the used parts collection supervisor. He can then present these signatures to the Parts Stores Department and get the requested part.

In the proposed system, the mechanic will use a Materials Request Form (MRF) and first get his manager's signature and the maintenance engineer's signature on the MRF. The mechanic will then take the MRF and the broken/used component to the Used Parts Store (UPS). The UPS attendant will take the broken/used component, place it in storage, and place his signature on the MRF. The mechanic can then take the MRF to the Inventory Control Section of the Financial Department and exchange it for a Materials Approval Form (MAF). The mechanic takes the MAF to the Parts Stores, receives the new component, and the Parts Stores manager confirms in the EMIS that he has delivered the specified component to the specified mechanic. To expedite this process, the CAIP CNG Team also will evaluate the use of Part Delivery Personnel with CTA and GCBC management during the Task 5.2 development.

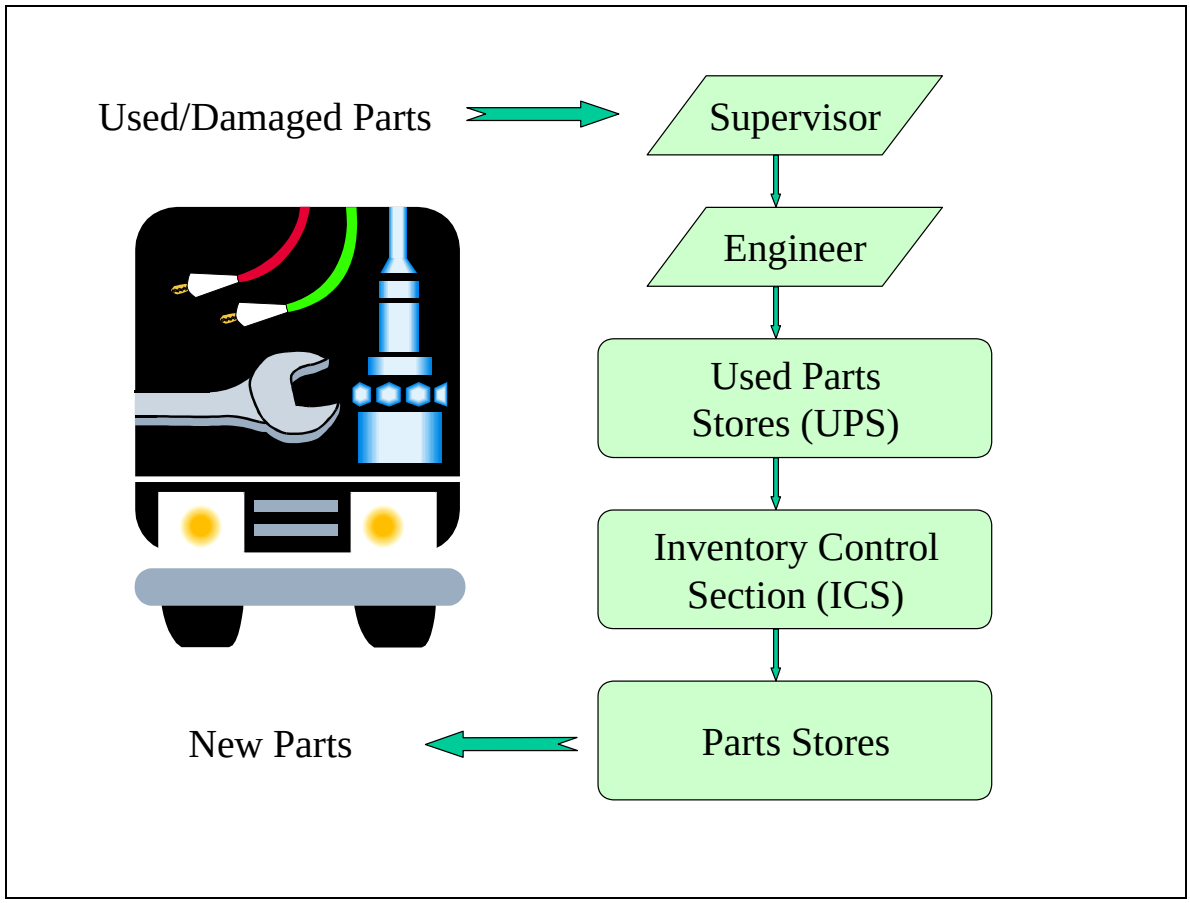
Although the proposed system may sound cumbersome, the CTA and GCBC mechanics already use a similar system, so training to carry out a new procedure is not necessary. The only addition to the existing procedure is the recording of the materials usage in the EMIS, which will provide an electronic inventory control, as well as materials accountability throughout the CNG Parts Stores. New parts will have to be specifically requested and their issuance from the Parts Stores will be electronically recorded and tracked by mechanic–supervisor–engineer–UPS manager signatures. This system allows for constant tracking of parts inventories, while simultaneously reducing the opportunity for parts to be mishandled or lost.

Figure 6 shows a proposed flow diagram for the electronic tracking and issuance of spare parts in the new CNG garages. The integration of the EMIS system with the purchasing department is discussed in Section 3.5

3.1.3 Maintenance Scheduling System

One of the other major benefits of the proposed EMIS is that it can be used to help the Maintenance Department schedule CNG vehicles for their preventive maintenance procedures. When the vehicles enter the fueling lanes on return from their daily shifts, the fueling lane personnel will use the EMIS to collect data on fuel consumption, distance the vehicle traveled, and any damage that occurred to the vehicle. By having electronic records of the distances traveled per day, the Maintenance Department will know the vehicle odometer readings and be able to predict when vehicles will encounter required preventive maintenance milestones. The EMIS will serve to remind the

Figure 6
Parts Request Flow Chart



maintenance managers when their vehicles are due for service and allow them to be prepared. This system can be quite flexible and give scheduling data several days to several weeks in advance of service dates, allowing maximum flexibility for Maintenance Department management to maximize the efficiency of their operations.

Because the CNG vehicles and their associated maintenance will be new to the CTA and GCBC maintenance staffs, the CNG Team is concerned about overloading the maintenance personnel with too many new procedures and too much new technology. Adding exposure to new computer systems and electronic maintenance scheduling will only exacerbate the problem. In an effort to reduce this overload, the Maintenance Departments' computer staff (which will be hired during garage and EMIS development) can implement the maintenance-scheduling program. The interface with the computer output can be limited to paper reports (in Arabic) for maintenance supervisors and personnel. By limiting this interface, the maintenance personnel, whose primary function is to keep the CNG vehicles operating properly, will not be forced to become CNG and computer literate at the same time. This also will benefit the overall project by not slowing the overall vehicle implementation while maintenance staff participate in computer system training.

3.1.4 CNG Fuel System Inspection and Maintenance

The majority of past CNG fuel system failures in North America could have been prevented through the proper usage of visual inspection programs. In fact, the major concern about physical damage to CNG fuel containers on vehicles leading to container ruptures in Egypt can be all but eliminated through proper visual inspection procedures. Therefore, aside from the routine and preventive maintenance applicable to the standard chassis and body components, the addition of natural gas fuel systems to the new transit buses will strictly require the Performance Teams to carry out documented inspections of these fuel system components.

The CAIP CNG Team will work with the chassis and fuel system component manufacturers to develop acceptable inspection procedures and intervals for all of the fuel system components, including containers, pressure relief devices, and high pressure fuel lines and fittings. This inspection procedure development will include determination of specific, necessary measurement equipment, damage measurement and determination criteria, allowable repair procedures, inspector training criteria, container labeling requirement, and even equipment to condemn containers that are not repairable.

This inspection development task with the chassis and fuel system component manufacturers will include development of clear guidelines for repair or replacement of specific components depending on potential damage or defective component scenarios. During the initial implementation of original equipment manufacturer (OEM) CNG vehicles in North America and Europe, many vehicle users were confronted with unforeseen mechanical difficulties with fuel system components. The users did not have clear guidelines for their mechanics to follow for repair or replacement of these components. While many of these difficulties have been resolved in other countries, issues like this could occur in Egypt during this initial implementation. The goal of the CNG Team will be to have clearly defined guidelines and relationships with the chassis and fuel system component manufacturers to solve these problems as efficiently as possible.

3.2 Technical Department

The new Technical Department in these garages will be in charge of implementing and maintaining most of the new, technologically advanced systems with which the CTA and GCBC staffs are not familiar. These include the Electronic Maintenance Information System (EMIS) first discussed in Section 3.1.2. The Technical Department also will be in charge of quality assurance/quality control (QA/QC), technical training for CNG garage personnel, and assembling a clearinghouse or library for all technical literature regarding natural gas vehicles and fueling stations.

3.2.1 Electronic Maintenance Information System

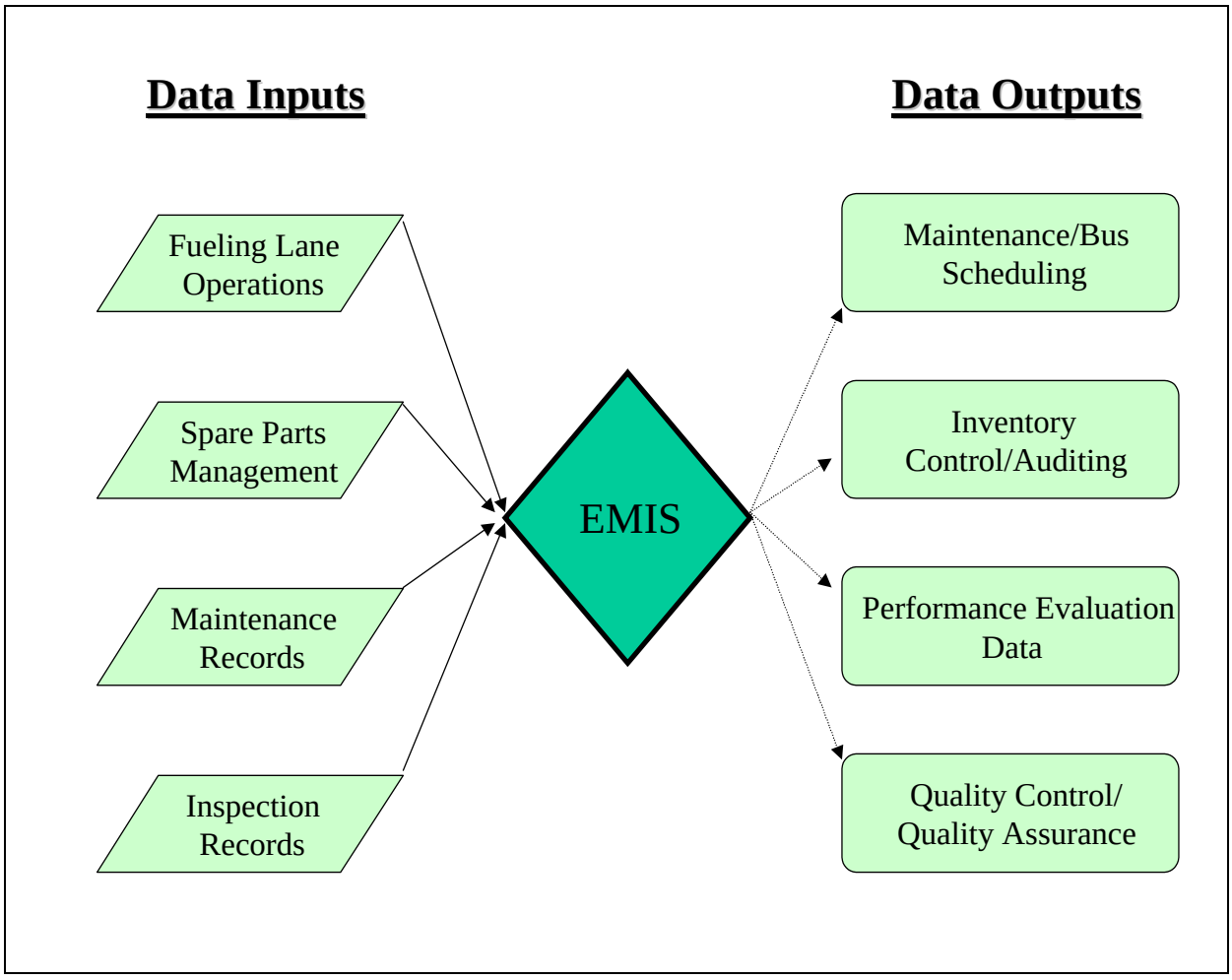
The EMIS that the CNG Team is proposing will be the heart of CTA and GCBC maintenance operations, spare parts management, and even vehicle performance evaluation. Interface with the EMIS will begin as soon as vehicles enter the fueling lanes, on return from their regular transit shifts, continue through the maintenance scheduling and spare part inventory control, and finish with information about how each vehicle in the fleet is performing.

Figure 7 shows a potential input/output diagram for the EMIS.

Fueling Lane Operations

As the CTA and GCBC CNG vehicles return at the end of their shifts and enter the fueling lanes, data acquisition using the EMIS system will begin. The fueling lane personnel will be responsible to use the EMIS to record the arriving bus' identification number, the vehicle's odometer reading, how much fuel was metered into the vehicle,

Figure 7
EMIS Input/Output Diagram



any damage found during the fueling lane functional testing, any fluid consumption found during functional testing, and whether the vehicle was sent to be parked or routed for additional maintenance.

This initial data collection will allow CTA and GCBC management to electronically track necessary information about each of their vehicles, how it performed in the past including fuel and spare parts consumption, and determine when it is due for future maintenance. This vehicle-by-vehicle data will be collected through computer terminals (possibly hand held units) located in the fueling lanes. These terminals will electronically send this data directly into the EMIS system. The computer will store this information in the appropriate file for each vehicle.

Maintenance Scheduling

Based on the odometer data collected, chassis and body manufacturer requirements for preventive maintenance, and other unique maintenance data that are collected, the EMIS will produce maintenance scheduling reports. These reports will notify the Maintenance Department personnel when specific vehicles are due for maintenance. Because the system will collect all historical odometer data for each vehicle, the EMIS will be able to determine the average daily distances traveled and predict when vehicles will be due for preventive maintenance. This data can be generated daily or well in advance, to allow the Maintenance Department to schedule vehicles more efficiently.

Maintenance Data Collection

The CNG Team also envisions that the EMIS will be used to enforce mandatory maintenance procedures by requiring that reports on those procedures be filed in the system for each vehicle. An example of this type of reporting would be the required inspections of the CNG fuel systems. As each required inspection is completed, the inspection report would be electronically filed in the EMIS. In this way, not only will the EMIS remind the maintenance department that the inspection is required, but it will also serve as repository for inspection reports to prove that they have been completed.

This type of reporting system also could be useful for tracking any information or reporting that is required by the chassis or body manufacturers to comply with their warranty regulations. That way, if a manufacturer is hesitant to provide warranty support on a specific issue that requires official reporting, the information will be readily available to expedite solving the problem.

The EMIS will provide many benefits, and one of the most important is the ease with which the bus companies can implement a CNG bus performance monitoring system. By simultaneously tracking all parts usage, maintenance scheduling, and daily vehicle usage data, the Technical Department will be able to determine how each and every

CNG vehicle in the CTA and GCBC fleets is performing. Box 1 gives a description of the proposed "Performance Monitoring" System.

Box 1

Performance Monitoring System

The operation of the new CNG garage will be organized around the EMIS. This system will be used to record and monitor every aspect of the performance of the new CNG vehicles. It will also be used to track and account for the use of labor time, spare parts, supplies, and other resources, as well as scheduling preventive and corrective maintenance. Reports and analyses provided by the EMIS will provide essential responses and quality measurements for the continuous quality improvement program. By means of this system, data on the performance of each bus, each performance team, and even of each driver and mechanic, will be made available on a continuous basis, not only to bus company management, but also to the teams themselves.

Among the types of information and statistical data tracked and reported by the EMIS will be the following:

- Daily fuel consumption per kilometer by each bus, compared to past performance by that bus and driver and to fleet averages (anomalies in fuel consumption may indicate maintenance problems, or a need for more training on driving techniques);
- Daily consumption of fluids and other supplies by each bus, compared against past performance and fleet norms for all buses;
- Daily kilometers operated by each bus, compared against past performance and fleet norms;
- On-road service calls, by type of incident, performance team, and mechanic responsible (if maintenance related), bus, and bus driver;
- Consumption of spare parts and supplies by bus, performance team, and the fleet as a whole; existing parts and supplies inventories; and the expected period that the existing inventory will last, based on historical consumption patters. This will be used to ensure that adequate (but not excessive) parts and supplies inventories are on hand at all times.

Supervisors, managers, and the team members themselves will use the outputs from this system to assess performance and identify any problem areas where attention or additional training may be required. To ensure that all team members are able to take advantage of this system, they will undergo training and receive extensive coaching in using the EMIS, as well as in the concepts and techniques of continuous quality improvement.

Performance Monitoring System

Spare Parts Management

As explained in Section 3.1.2, the maintenance personnel will be required to request any spare parts through the Inventory Control Section (ICS) of the Financial Department. At each step in the process, when used/damaged parts are delivered to the UPS, when new parts are approved by the ICS, and when the Parts Stores delivers the new spare parts, the EMIS system will be used to record the transactions.

Because the EMIS will know the initial spare parts inventory of the CNG Parts Stores, as each additional spare part is distributed, the system will be updated and the resulting inventory of each component will be known instantly. As the inventory of a specific part gets low, the Purchasing Department will be notified by the EMIS and will know that these parts need to be ordered before the stock is depleted completely.

For auditing purposes, the EMIS will have tracked all of the incoming used parts submitted during approval for replacement components. All of the outgoing new spare parts, and the signatures given in approval of the transaction, are tracked as well. When the Auditing Department audits the Parts Stores and the Purchasing Department, they will have specific data on exactly what should be in inventory. If there is a discrepancy in any parts inventory data, the UPS inventory also can be used to confirm inventory quantities.

This type of parts management system offers another benefit: the EMIS tracks the total number of parts used and the period over which they were used. Parts consumption data is readily available for budgeting in the Financial Department.

3.2.2 Quality Assurance/Quality Control

The QA/QC section of the Technical Department will play a role similar to the one it currently has at the CTA and GCBC diesel garages. This includes monitoring the quality of service maintenance, vehicle performance (including overall fuel, oil, and parts consumption), vehicle repairs, correlation between distances traveled and fuel consumption, revenue per kilometer, and proper flow of required paperwork inside the respective garages.

In addition to these tasks, the QA/QC section will have the new responsibility of confirming all CNG fuel system inspection procedures. Although the Maintenance Department will be required to electronically file all fuel system inspection reports, the actual paper checklist inspection report must be filed with the QA/QC section. Although this might seem overcautious, it is essential that all required fuel system inspections are done in a timely manner. This task will be aided by the EMIS, which will provide electronically filed reports to the QA/QC section directly. The QA/QC staff will need to confirm that they have received the associated paper reports.

3.2.3 Training in Conjunction with CTA's Central Administration for Training Affairs

Because the content of the required CNG training for new CNG vehicle operators, mechanics, and technicians will be fundamentally new and technologically advanced, the training section should be part of the Technical Department. The training section will be in charge of coordinating all training with the CTA Central Administration for Training Affairs. Due to its overall smaller size, GCBC uses CTA's Central Administration for Training Affairs for its training needs. An extensive report on training needs was addressed in PBPM#3 (Part 1).

During the deployment and operation of the initial pilot fleets at CTA and GCBC, the CNG Team will monitor operations and maintenance closely in order to identify and correct any deficiencies in the training curricula. Once any necessary changes are made to the curricula, training will resume on a continuous basis. Continuous training will serve three purposes:

- Refresh and update training already given to CNG operations and maintenance staff;
- Career advancement training for higher-level positions;
- Expansion of the supply of trained staff as required by the expansion of the CNG bus and minibus fleets.

3.2.4 CNG Information Clearinghouse

Because this will be the first large-scale implementation of CNG transit buses at CTA and GCBC, it is important for each facility to have immediate access to technical data and safety information about the use of CNG and natural gas vehicles, in general. The CNG clearinghouse/library in each garage will be an integral part of the Technical Departments. It will also serve to answer any questions or concerns that new mechanics may have, even after the general and specific training programs in which they will participate.

One of the unanticipated problems in some new CNG transit garages in North America was the lack of readily available information on natural gas vehicles for garage employees. Many employees in these garages received basic training, but did not have easy access to all the information they may have wanted. This situation lead to many employees being uncomfortable with or afraid of the vehicles they were working on, and consequently resulted in poor labor relations and employee performance.

Because CNG technology is so new in this application in Egypt, it will be important to have readily available information for technicians performing maintenance and repairs directly on CNG vehicles. Employees involved with work not directly connected to the CNG fleet should also have access to materials in the library/clearinghouse. The CNG clearinghouse in the Technical Department can serve both purposes.

3.3 Safety Department

The Safety Department will be in charge of occupational safety, fire fighting, and garage security. Occupational safety requirements cover the "dos and don'ts" of using natural gas vehicles in the CTA and GCBC garages. These requirements ensure that the CNG vehicle usage, fueling, and maintenance are being done in a safe manner and follow all the written safety rules published by the manufacturers of the vehicles and fueling stations. The occupational safety personnel also will be required to endorse the CNG fuel system inspection procedures, intervals, and accuracy. This additional effort by the Safety Department, combined with QA/QC confirmation of the inspections, will ensure that the required inspections are being done and being performed correctly.

One of the most important duties of the Safety Department will be site security. The CNG buses will be brand new at the CTA and GCBC garages, and the natural gas fueling station equipment will be substantially different from the current diesel equipment. It will be imperative that the security staff keeps a watchful eye on the entire facility. Opportunities for vandalism, and even sabotage, of new equipment is not uncommon in major metropolitan areas. While the entire CAIP team is working to increase public awareness about the safety of natural gas vehicles, it will still be necessary to have security personnel enforcing rules against trespassers on the properties.

3.4 Transportation Department

The main purpose of the Transportation Department is to ensure that buses are ready to operate each morning with drivers, fare collectors, and proper dispatching and route planning. This department also includes the bus fuelers and cleaners, because they are an integral part of readying buses for morning call. Because appearance and cleanliness will undoubtedly be part of the criteria on which the garage Performance Teams will be rated, the bus cleaning personnel also will be part of individual teams.

3.5 Financial Department

The proposed Financial Department will be in charge of the garage accounting, cashier, budgeting, purchasing, and inventory control. Purchasing and inventory control will play an integral role in the proposed parts management system and both sections will have direct links to the EMIS.

The EMIS will be designed to simultaneously warn the inventory control and purchasing sections that the Parts Stores are running low on a particular part or set of parts. When this happens and it is determined that there is an actual shortage, the purchasing section will interface with the corporate Purchasing Departments to obtain a new supply of parts.

3.6 Auditing Department

The Auditing Department will be directly in charge of monitoring the garage accounting, payroll, cashier, purchasing, and inventory control. This department also will play an integral role in maintaining the integrity of the proposed EMIS by conducting regular checks of the Parts Stores to confirm the EMIS inventory reports.

If the Parts Stores do not have inventory to match the EMIS inventory reports, the UPS can be audited as a second check on the electronic inventory. CTA and GCBC routinely store used parts, which are collected in the current diesel inventory control program, for up to 6 months before they are given up for public auction. Therefore, quarterly auditing of the Parts Stores should be done to take advantage of the UPS as a backup inventory control method.

3.7 Administration Department

The Administration Department will be in charge of garage personnel issues, payroll, secretarial functions, and overall housekeeping.

3.8 Legal and Labor Relations Departments

The Legal and Labor Relations Departments will play similar roles to these departments in the existing diesel garages.

4. Implementation

In order to implement the proposed changes from Section 3, the CNG Team has developed recommendations for garage staffing and for implementation of the new maintenance systems. The EMIS will be designed and implemented during Year 2. Because there will be a limited number of CNG vehicles at CTA (25 transit buses, 25 minibuses) and GCBC (25 transit buses) for the first year of operation, the staffing requirements will be lower. This initial period will be an ideal time to resolve any flaws with the new systems in the garages (especially the EMIS) and implement any unforeseen training programs that are necessary.

4.1 Staffing Requirements

The figures presented in Table 2 show the staffing requirements for four different potential staffing scenarios at the CTA and GCBC garages. The first scenario is for a garage housing 25 minibuses; the second a garage housing 25 full-size transit buses; the third a garage housing 25 minibuses and 25 transit buses; and the fourth a garage that houses 100 minibuses and 100 transit buses. For the proposed demonstration fleets, the CTA garage will house 25 minibuses and 25 transit buses, while the GCBC garage will house 25 transit buses.

The figures for transportation and maintenance personnel in these tables were developed based on the number of buses and the distance they operate per day. The initial calculations were made for a full garage with 100 transit buses and 100 minibuses. Because the initial CTA CNG facility will have 25 transit buses and 25 minibuses, and the initial GCBC facility will have 25 transit buses, the estimates were scaled down from the original calculations. The base (200 total vehicle) calculations for these figures are presented in the Appendix. Staffing requirements for the rest of the garage employees are estimates based on the CNG Team's experience with facility management in Egypt and the USA.

As one can see from the figures, the only difference in staffing between minibuses and transit buses will be the additional conductors (personnel who collect fares on the CTA and GCBC transit buses) in the transit buses. Traditionally, the CTA minibuses have not had a conductor and the driver collects fares as the passengers enter the vehicle. These initial proposed personnel requirements assume this will be the case with the new CNG minibuses. Changes in the CNG minibuses might preclude the driver from acting as the

Table 2
Personnel Requirements for CNG Transit Garages

Department	Number of Employees			
	25 Minibuses	25 Buses	25 Minibuses + 25 Buses	100 Minibuses + 100 Buses
General Manager	1	1	1	1
Auditing	2	2	2	3
Labor Relations	3	3	3	4
Legal	2	2	3	5
Transportation	87	147	228	824
Manager	1	1	1	1
Drivers	60	60	120	480
Conductors	0	60	60	240
Fare collectors	6	6	12	24
Route planing	4	4	6	14
Dispatchers	6	6	12	24
Fuelers	2	2	3	6
Cleaners	4	4	6	10
Other	4	4	8	28
Maintenance	67	67	107	307
Manager	1	1	1	1
Routine	7	7	14	60
Preventive	8	8	16	40
Repair	5	5	10	40
Specialized shops	40	40	60	160
Parts stores	6	6	6	6
Technical	13	13	13	18
Manager	1	1	1	1
QA/QC	4	4	4	6
Information system	2	2	2	4
Performance evaluation	2	2	2	2
Training	2	2	2	3
Clearinghouse	2	2	2	2
Safety	16	16	23	37
Manager	1	1	1	1
Industrial	3	3	4	12
Fire Fighters	4	4	6	12

Table 2 (Continued)
Personnel Requirements for CNG Transit Garages

Department	Number of Employees			
	25 Minibuses	25 Buses	25 Minibuses + 25 Buses	100 Minibuses + 100 Buses
Security	12	12	12	12
Financial	14	14	16	23
Manager	1	1	1	
Accounting	2	2	3	6
Cashier	4	4	4	4
Budgeting	1	1	1	2
Purchasing	2	2	3	6
Inventory control	4	4	4	4
Administration	20	20	24	30
Manager	1	1	1	1
Personnel	3	3	4	6
Payroll	3	3	4	6
Secretary	2	2	2	2
Garage Administration	6	6	8	10
Housekeeping	5	5	5	5
TOTAL	225	285	420	1,225

conductor, especially if the buses are longer and have more then one set of doors. Personnel requirements will have to be modified if such changes occur.

4.2 Management Program Implementation

Aside from the generic staffing requirements, implementation of the maintenance systems proposed in Section 3 would require some specific changes to the current CTA and GCBC institutional structures. These changes will affect the inter-departmental reporting relationships, as well as the composition of the garage staff.

4.2.1 Inter-departmental Reporting

One of the most fundamental changes at CTA and GCBC due to the introduction of CAIP CNG transit vehicles will be the development of inter-departmental relationships

that did not exist before. These new relationships will be necessary with the introduction of the EMIS. After implementation, the maintenance, technical, safety, financial, and auditing departments will be electronically linked to maintain proper communication, maintenance scheduling, parts supply, and safety inspections.

The CAIP CNG Team anticipates that any initial resistance to the introduction of this inter-connected EMIS on the part of the managers of the various new departments will disappear as the managers learn to use the new system and understand its advantages. When the system is fully implemented, the department managers will accept that performance throughout the facility will be better, with the same (or less) effort.

The CNG Team will work with the department directors to explain how these new inter-departmental relationships can provide the continuous quality improvement. In addition, those relationships will enable full accountability for time, spare parts, supplies, and other resources that are necessary to ensure the success of the CNG implementation.

4.2.2 Specific Staffing Requirements

While the bulk of the CTA and GCBC staffs will be re-trained for CNG transit operations using the plan laid out in PBPM#3 (Part 1), several staff members will be required to implement the comprehensive EMIS. These staff members should have experience in implementing and operating computerized database management systems. Because no employees with extensive computer database experience were discovered during the initial CAIP Training Needs Assessment, the CNG Team recommends that CTA and GCBC recruit and hire these Computer Management Professionals (CMPs) from outside their current staffs.

These CMPs will be involved in the initial installation of the EMIS and should remain as permanent employees of CTA and GCBC. The CMPs will be well trained and able to support the CAIP training team as it trains the auditing, purchasing, and inventory control personnel. The most important role the CMPs will have to play in the new garages is as the interface between the maintenance personnel, who have not previously used computerized management systems in the workplace, and the EMIS.

As mentioned in Section 3.1.3 above, the CMPs will be the interface for the maintenance personnel during the initial stages of the EMIS implementation. This will reduce the potential overload on the maintenance personnel, which could result if they are required to become familiar with computers and MIS along with the unfamiliar CNG technology.

4.3 Design and Implementation of the EMIS

The features and functions of the proposed EMIS are detailed in Section 3. The actual design and implementation of the network computer system to execute those features

and functions will be carried out in Task 5.5, in parallel with the development of the garage management procedures in Task 5.2.

Task 5.5 will begin early in Year 2 with recruitment of the computer professionals necessary to design the EMIS (January–February 1999). After CAIP locates appropriate personnel, the team will begin designing the software and hardware specifications to implement all the features of the EMIS. After the design phase, the team will work with the CNG garage design team to coordinate procurement of the necessary computer equipment and installation of the hardware and software with the completion of the garages at CTA and GCBC. The team will then carry out tests and trials to ensure the successful operation of the software and hardware systems in the garages.

After completion of the trial period in the garages, the team will help to implement the EMIS system, train CTA and GCBC staff in its use, and provide support to ensure it operates properly. This implementation period will be for at least 1 month and will be scheduled to occur before the CNG bus fleet begins arriving in the CTA and GCBC garages. This extra month will allow the garage staff to begin using the system, discover any potential bugs that might not have been found during the trial period, and begin practicing the new parts control procedures and maintenance practices before the buses actually arrive.

5. Conclusion

The baseline study confirmed that the CAIP CNG Team's proposed institutional structure is feasible under the existing CTA and GCBC corporate structures. The proposed organizational structure is sufficiently similar to the existing CTA and GCBC garage organizations that employees should not find it difficult to adapt. By retaining a similar structure, the bus companies' employees will not be compelled to adapt to too many new activities at once.

The goal of the CAIP CNG Team for the proposed organizational structure for CNG garages at CTA and GCBC is a new management system, similar to the present one, but with improvements to enhance the productivity of garage employees and administrators. These changes primarily will be the introduction of continuous quality control improvement and integration of an electronic parts/maintenance control system into the existing garages.

After the preliminary review with management from the bus companies, it is clear that the chairmen of CTA and GCBC were pleased with the report findings and are ready to incorporate the proposed changes in their corporate structures. At CTA, the new Nasr City CNG facility will become a separate entity, with its own general manager reporting directly to the CTA chairman. At GCBC, the new Katameya CNG facility will become a new facility under the Branch Operations Section. The chairmen also agreed in principle with the management structure of the new garages, but they will review it in more detail during CAIP Task 5.2.

Once the rolling chassis suppliers are selected, the CNG Team will begin working with counterparts from the bus companies and with the engine and chassis suppliers to develop very detailed management procedures for the actual CNG bus and minibus O&M (Task 5.2). These procedures will include schedules for inspections, routine and preventive maintenance, management of spare parts and supplies, and procedures for monitoring, reporting, following up, and resolving maintenance problems. The exact details of the actual EMIS design will be reviewed and more fully developed during the implementation of CAIP Task 5.2.

Appendix:
CNG Facility Personnel Requirements

Main Assumptions

1. Fleet size (100 full size buses + 100 mini buses)	200 vehicles
2. Fleet utilization (80 percent)	160 vehicles
3. Fuel type	CNG
4. Bus size	12m
5. Mini bus size	8.5m
6. Operation shifts	2
7. Days in service/year	365 days
8. Average daily bus mileage	350 km
9. Employee working days/year (excludes weekends, vacations, holidays, and sick leave)	240 days
10. Driver and conductor working hours/day	9 hours
11. Driver and conductor working hours/year (240 × 9)	2,160 hours
12. Employee working hours/day (excludes lunch time, tea break, prayer time, and other)	5 hours
13. Employee working hours/year (240 × 5)	1,200 hours
14. Maintenance schedule	
Daily inspection	Daily
Daily service (washing, cleaning, consumable check, etc.)	Daily
Preventive maintenance	
Service A	10,000 km
Service B	20,000 km
Service C	60,000 km
First overhaul	400,000 km
15. Maintenance estimates (hours of labor)	
Daily inspection	0.5 hours

Main Assumptions (Continued)

Daily service (washing, cleaning, consumable check, etc.)	0.5 hours
Preventive maintenance	
Service A	5 hours
Service B	10 hours
Service C	20 hours
First overhaul	80 hours

Garage Staffing Transportation/Operation Estimate (Labor Hours)

Bus working hours/year (365 × 0.8 × 18)	≅	5,256
Number of drivers/bus (5,256 ÷ 2,160)	≅	2.4
Total number of drivers (200 × 2.4)	≅	480
Total number of conductors (100 × 2.4)	≅	240
Total number of fare collection (5% × 480)	≅	24
Total number of dispatchers (5% × 480)	≅	24
Total number of operators (3% × 480)	≅	14
Total number of inspectors (3% × 480)	≅	14

Maintenance Department Staffing Estimate

Distance covered per bus/year (365 × 0.8 ×3500)	≅	100,000 km
Total distance covered/year (200 × 100,000)	**≅**	**20,000,000 km**
Number of maintenance overhauls (20,000,000 ÷ 400,000)	≅	50 labor hours.
Service C (20,000,000 ÷ 60,000) - 50	≅	283 labor hours
Service B (20,000,000 ÷ 20,000) -333	≅	667 labor hours
Service A (20,000,000 ÷ 10,000) -1000	≅	1,000 labor hours
Daily service (365 × 0.8 × 200)	≅	58,400 labor hours
Daily inspection (365 ×0.8 × 200)	≅	58,400 labor hours
Total maintenance estimate (50 × 80) + (283 × 20) + (667 × 10) + (1000 × 5) + (58,400 × 0.5 × 2)	**≅**	**79,730 labor hours**

Maintenance Department Staffing Estimate (Continued)

Total repair estimate (79,730 × 0.5)	**≅**	**39,865 labor hours**
Total maintenance and repair estimate	**≅**	**119,595 labor hours**
Total number of		
Mechanics (119,595 ÷ 1200)	≅	100
Electricians and battery electricians (33% × 100)	≅	33
Air conditioning technicians (20% × 100)	≅	20
Body repair technicians (100% × 100)	≅	100
Machining technicians (20% × 100)	≅	20
Painters, carpenters, upholsters, etc.	≅	27
Total	**≅**	**300**